PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventors: PETER DU FOSSE and GEORGE EDWARD GLENFIELD

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COMPLETE SPECIFICATION

Reverse Magnetron having a Circular Electric Mode Purifier in the Output Waveguide

We, S-F-D LABORATORIES, INC., a corporation organised under the laws of the State of New Jersey, United States of America, of 8000 Rahway Avenue, Union, New Jersey, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement: —

The present invention relates in general to reverse microwave tubes and, more particularly, to an improved reverse magnetron having a circular electric mode purifier in the output waveguide, whereby a circular electric mode output of increased purity is obtainable. Tubes according to the present invention are especially useful as output tubes for high peak power radars operating in the frequency range of 30 GHz or higher.

Heretofore, reverse magnetrons have been characterised by a centrally disposed circular electric mode cavity resonator coupled to an array of outwardly directed vane resonators which interact in a magnetron interaction region with a stream of electrons produced by a cathode emitter ring which surrounds the anode array. The output is taken out axially of the tube through a circular electric mode waveguide coupled to the circular electric mode cavity. Such a tube is described in the specification of Patent No. 1,061,711.

It has been discovered that there is a tendency in these tubes for the output wave energy to convert from the desired $TE_{0,1}$ mode to other non-circular electric modes. The precise reason for this conversion process is not fully understood. However, the dominant mode in the output waveguide and circular electric mode cavity is not the operating $TE_{0,1}$ mode and it is known that perturbations in the output waveguide such as those associated with the output microwave window assembly or output coupling device, which couples energy from the circular electric cavity, can produce a conversion of $TE_{0,1}$ mode energy into non-circular modes. Such conversion is troublesome since the utilisation devices to which the tube supplies power are designed for the $TE_{0,1}$ mode and substantial amounts of power in other modes can cause arcing and burn-out of such devices and unwanted radiation of interfering power.

According to the present invention there is provided a reverse magnetron microwave tube apparatus including a circular electric mode cavity resonator, an array of vane resonators projecting outwardly from said cavity resonator, said cavity resonator having an array of coupling slots communicating between said cavity resonator and said array of vane resonators for coupling together the two resonant systems to form a composite anode microwave circuit, a cathode emitter structure surrounding said vane array in spaced relation to define a crossed-field interaction region therebetween for generating microwave energy in said anode circuit, a circular electric mode output waveguide coupled to said cavity resonator for extracting generated microwave energy therefrom, and a selective mode absorber coupled into said output waveguide for absorbing wave energy of non-

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circular electric mode waves therein and not appreciably absorbing wave energy of the $TE_{0,1}$ mode therein.

In a preferred embodiment of the invention, the mode absorber takes the form of an array of transversely directed narrow slots in a tubular portion of the output waveguide assembly. The slots open outwardly into a coaxially disposed mode absorber for absorbing the energy from such non-circular electric modes. The transverse slots and mode absorber element do not interfere with the desired $TE_{0,1}$ mode as the currents associated with this mode are all parallel to the slots and the slots are relatively narrow. Thus, the output of the tube incorporating the mode absorber is a substantially pure $TE_{0,1}$ mode.

The invention will be described, by way of example, with reference to the accompanying drawings wherein:

Fig. 1 is a perspective view of a reverse magnetron according to the present invention,

Fig. 2 is an enlarged sectional view of the structure of Fig. 1 taken along the line 2—2 in the direction of the arrows, and

Fig. 3 is an enlarged sectional view of the structure of Fig. 2 taken along the line 3—3 in the direction of the arrows.

Referring now to Fig. 1, a reverse magnetron tube 1 is shown including a generally cylindrical central body structure 2, for example of copper, which contains the microwave anode circuit and cathode emitter and is evacuated to a low pressure, such as 10^{-8} Torr. A lead-in high voltage insulator assembly 3 depends from the main body 2 to bring in the cathode voltage, for example −23 KV. A tuner housing assembly 4 is mounted on one axial end of the main body 2 and an output circular electric mode waveguide and output window assembly 5 is mounted on the other axial end of the main body 2.

Referring now to Fig. 2 the tube will be described in greater detail. A circular electric mode cavity resonator 6 is disposed centrally of the tube main body on its central axis. The cavity resonator 6 is defined by a region bounded on the sides by a cylindrical anode wall 7 and on one end by a conductive end wall 8 and on the other end by a tuning disk 9, forming the other end wall of the cavity 6.

An array of vane resonators 11 project outwardly from the side wall 7 of the cavity. An array of axially directed coupling slots communicate through the side wall 7 with alternate ones of the vane resonators for locking the π mode of the vane resonator system to the $TE_{0,1,1}$ mode of the cavity resonator 6. A cathode emitter ring structure 12 surrounds the vane resonator array 11 to define an annular cross-field electronic interaction region 13 therebetween. A pair of axially spaced cylindrical magnetic pole pieces 14 and 15 are disposed on opposite sides of the interaction region 13 to provide therethrough an axially directed magnetic field which is orthogonal to the electric field between the cathode ring structure 12 and the vane array 11, operating at anode potential. A pair of C-shaped magnets 16, only partially shown, are coupled to the main body 2 externally thereof for supplying the magnetomotive force to the pole pieces 14 and 15.

The π mode magnetron operation of the vane resonator array supplies energy to the $TE_{0,1,1}$ cavity 6. An output circular electric mode waveguide 17 is disposed axially of the tube 1. A wave-permeable vacuum-tight window 18 is sealed across the waveguide 17. Output wave energy at the operating frequency of the tube, such as 35 GHz, is coupled out of the cavity 6 around the perimeter of the disk 9 and through the waveguide 17 to a suitable load or utilisation device, not shown. A conductive rod 19, mounted on the centre line of the cavity 6, supports the disk 9 and also serves as the cavity tuner by varying the axial position of the disk 9. The rod 19 is actuated by known means and is sealed to the tube body 2 by a gas-tight flexible bellows 21.

The cathode emitter ring structure 12 is supported from the end wall 22 of the cylindrical tube body structure 2 by means of a plurality of axially directed insulator assemblies 23 and spring fingers 24.

Referring now to Figs 2 and 3, the output selective mode absorber or purifier will now be described in detail. An array of transverse slots 31 are cut through the side wall of the cylindrical output waveguide 17 in the region between the output window 18 and an output waveguide mounting flange 32. The slots 31 are, for example, 0.032″ wide and are provided in pairs which enter the guide 17 in the transverse plane, but from opposite sides of the guide 18, in such a manner that each slot 31 subtends about 150° of circumferential arc of the guide 17. The pairs of slots 31, for example 7 in number, are axially spaced apart by a metal strip, which, for example, is also 0.032″ wide so as to provide equal widths of metal and slot taken in the axial direction of the guide 17. Also axially adjacent pairs of slots 31 are so staggered that they cut into the guide from sides at right angles to each other. In this manner, the axially conducting path left between the ends of the slot pairs 31 is caused to meander around the successive circumferentially overlapping pairs of slots 31, whereby axial currents are heavily coupled to the slots 31.

The waveguide 77 is formed by a cylindrical tube, for example of brass, which is nickel plated. Typical dimensions of the tube 17 at 35 GHz are inside diameter

0.504″, outside diameter 0.697″ and a length of 1.358″. The outside diameter of the tubular waveguide 17 is cut down in the region surrounding the slots 31 to provide a wall thickness of 0.015″ or about one-half the slot width to increase further the coupling of wave energy therethrough. A cylindrical wave energy-absorbing member 33, for example of carbon-impregnated alumina ceramic 0.627″ I.D., 0.687″ O.D. and 0.875″ in length, surrounds the slotted region of the output guide for absorbing wave energy coupled thereto through the slots 31. Both the output waveguide 17 and the mode absorber 33 are disposed coaxially of the cylindrical pole piece 14. The energy absorber 33 forms a close mechanical fit over the waveguide 17 with only about 0.001″ clearance. The pole piece 14 is formed with about 0.005″ cold clearance to the outer diameter of the absorber element 33. Heat generated in the absorber 33 by dissipation of wave energy therein is conducted from the absorber 33 to the pole piece which thereby serves as a heat sink for the absorber 33.

In use, non-circular electric mode wave energy in the $TE_{0,1}$ mode output signal, as coupled out of the circular electric cavity 6, is heavily coupled to the lossy-mode absorber 33 and dissipated therein. However, the signal wave energy in the desired $TE_{0,1}$ mode is not appreciably coupled to the slots 31 and, thus, passes through the guide unperturbed and emerges from the selective mode absorber region in purified $TE_{0,1}$ form.

WHAT WE CLAIM IS:—

1. A reverse magnetron microwave tube apparatus including a circular electric mode cavity resonator, an array of vane resonators projecting outwardly from said cavity resonator, said cavity resonator having an array of coupling slots communicating between said cavity resonator and said array of vane resonators for coupling together the two resonant systems to form a composite anode microwave circuit, a cathode emitter structure surrounding said vane array in spaced relation to define a crossed-field interaction region therebetween for generating microwave energy in said anode circuit, a circular electric mode output waveguide coupled to said cavity resonator for extracting generated microwave energy therefrom, and a selective mode absorber coupled into said output waveguide for absorbing wave energy of non-circular electric mode waves therein and not appreciably absorbing wave energy of the $TE_{0,1}$ mode therein.

2. Apparatus according to claim 1, including an evacuated structure enveloping said anode circuit and cathode emitter, and wherein said output waveguide communicates with said circular electric mode cavity through a wall of said evacuated structure, a gas-tight wave-permeable window being sealed across said waveguide and forming a portion of said evacuated structure, and wherein said selective mode absorber is disposed in said output waveguide in a portion thereof external to said evacuated structure.

3. Apparatus according to claim 2, wherein said output waveguide includes a tubular portion external to said evacuated tube structure, and wherein said selective mode absorber includes an array of slots formed in said tubular portion directed transversely to the longitudinal axis of said tubular portion and a wave energy-absorbing member disposed at the outside circumference of said slotted portion of said tubular waveguide portion, said slots providing wave energy communication passageways between the interior of said waveguide and said energy-absorbing means for absorbing wave energy of the non-circular electric modes within said output waveguide while not appreciably absorbing energy of the $TE_{0,1}$ mode within said output waveguide.

4. Apparatus according to claim 2 or 3, wherein said selective mode absorber is disposed in said section of output waveguide between said microwave window and an output flange mounted on said output waveguide, forming an integral portion of the tube apparatus and defining an output terminal of the tube.

5. Apparatus according to claim 3 or 4, including a magnetic pole piece forming a part of said enveloping evacuated tube structure and disposed surrounding both said slotted portion of said output waveguide and said wave energy absorbing member the pole piece being arranged to cool said energy-absorbing member by conduction to said pole piece.

6. Apparatus according to claim 5, wherein said energy absorbing member is tubular and coaxial with said surrounding pole piece and said surrounded slotted tubular waveguide portion.

7. Apparatus according to any of claims 3 to 6, wherein said slots are axially spaced with successively axially spaced ones of said slots circumferentially overlapping in extent and staggered as to their circumferential centres.

8. Apparatus according to any of claims 3 to 7, wherein the radial wall thickness of the slotted portion of said slotted tubular waveguide is less than the axial width of said slots.

9. A reverse magnetron microwave tube apparatus, substantially as hereinbefore described with reference to the accompanying drawings.

REDDIE & GROSE,
Agents for the Applicants,
6, Bream's Buildings,
London, E.C.4.

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1161385 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

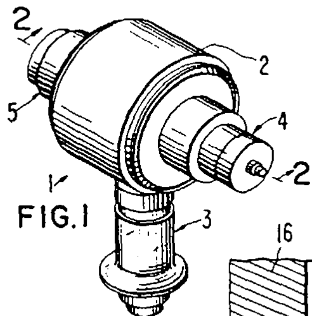


FIG.1

FIG.2

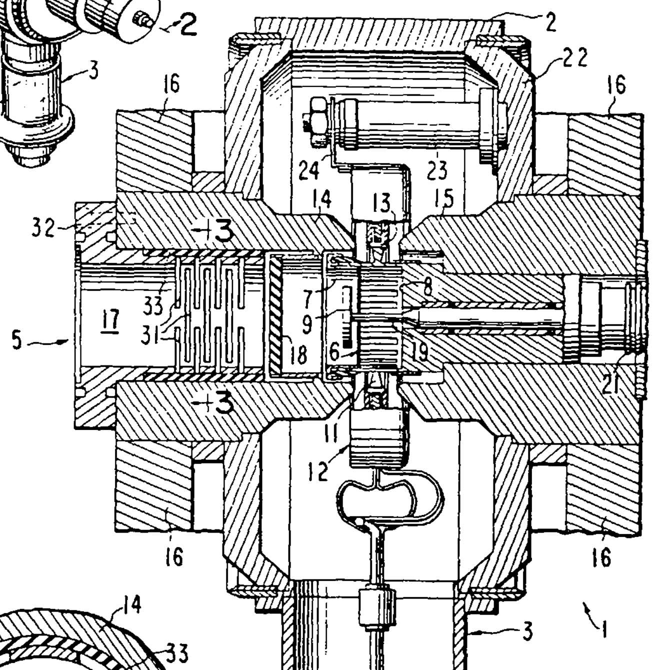
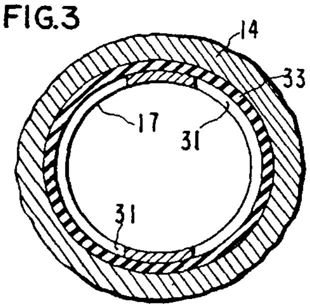


FIG.3



PATENTS ACT, 1949

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The following corrections were allowed under Section 76 on 14th November 1969

Page 1, line 4, *for* "8000" *read* "800"

THE PATENT OFFICE,
18th December 1969

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